The Journal of HEREDITY

WATTLED PORKER

(SEE PAGE 149)

Rh-Feeblemindedness

"Ghost-Patterned" Albinos

VOLUME 35 MAY, 1944 NUMBER 5

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The JOURNAL OF HEREDITY is published monthly by the AMERICAN GENETIC ASSOCIATION at 32nd Street and Elm Avenue, Baltimore, Md., and 1108 Sixteenth St., N. W., Washington, D. C. Address all communications regarding editorial matters to Room 205, 1108 Sixteenth St., N. W., Washington, D. C. Communications regarding the business management of THE JOURNAL OF HEREDITY may be addressed to the publication office, 32nd Street and Elm Avenue, Baltimore, Md., or to 1108 Sixteenth St., N. W., Washington, D. C. Entered as second-class matter February 24, 1923, at the postoffice at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in section 1103, Act of October 3, 1917, authorized December 29, 1918.

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The

Journal of Heredity

Vol. XXXV MAY, 1944 No. 5

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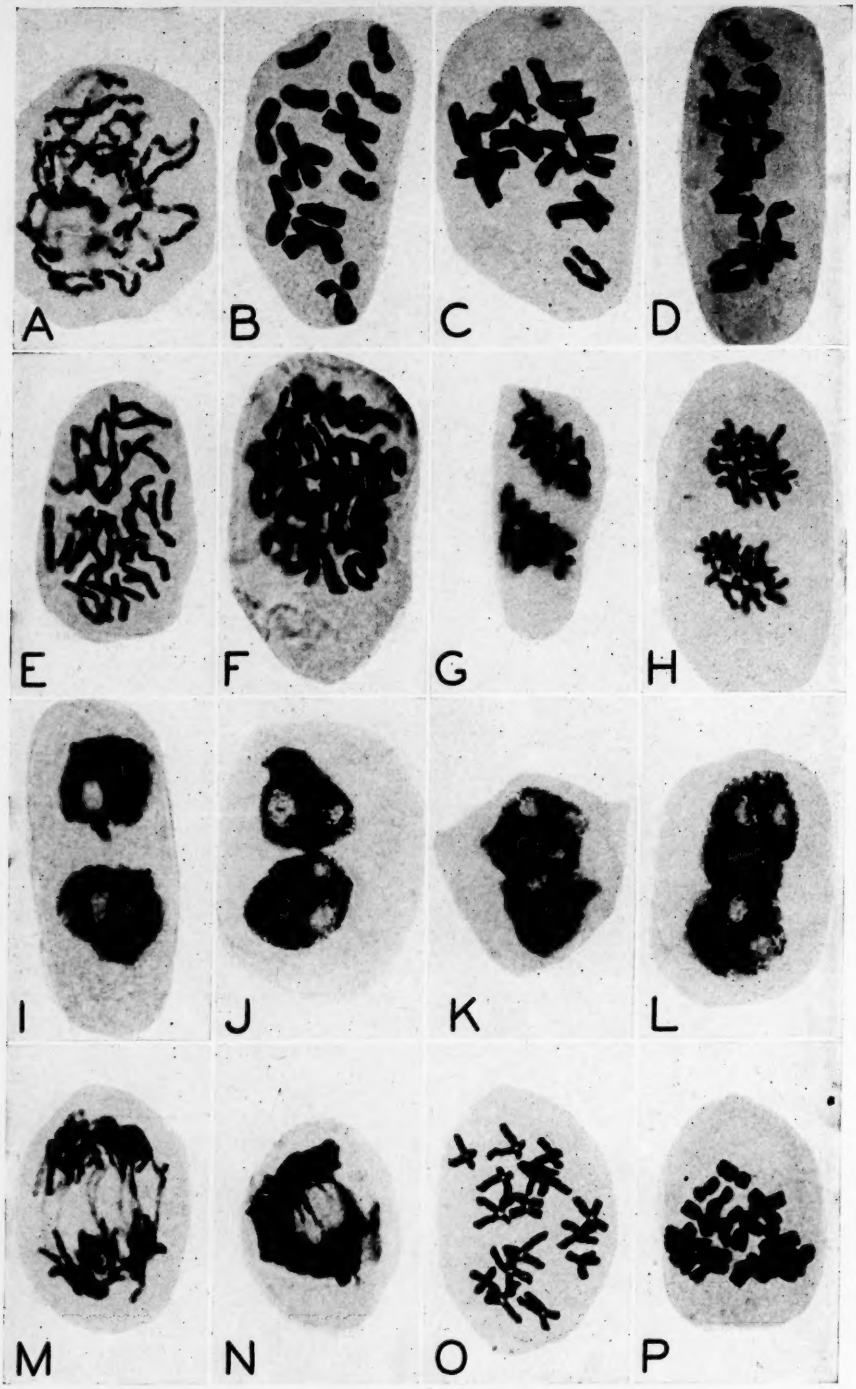


CHROMOSOMES IN VERATRINE-TREATED ONION ROOT-TIPS

Figure 1

All photomicrographs are aceto orcein smear preparations of onion root-tips (*Allium cepa*), × 1000. *A-F* shows the formation of a tetraploid cell in the complete absence of a spindle. *G-L* shows the formation of a tetraploid cell by nuclear fusion following incomplete spindle formation. The condition described as pseudo-anaphase, and pseudo-telophase with absence of cytokinesis is illustrated in this material. *M* and *N* illustrate tetraploid formation by means of "sticky" chromosome bridges. There is a striking contrast in appearance of chromosomes in nuclei treated with colchicine (*O*) and veratrine (*P*). The wide divergence of chromosome arms characteristic of colchicine-treated tissue (*O*) is easily distinguished from the more

VERATRINE, A NEW POLYPLOIDY INDUCING AGENT*

E. R. WITKUS AND C. A. BERGER
Biological Laboratory, Fordham University

A NEW substance capable of doubling the number of chromosomes in a cell has been found in veratrine sulphate. Veratrine is a mixture of alkaloids, chiefly veratrine and cevadine, with small amounts of two others. The cytological effects of this substance are similar to those of colchicine with a few interesting differences in the mechanism by which polyploidy is brought about.

It was found that a 0.1% solution of veratrine sulphate in tap water was the most effective concentration for root tips of the onion, *Allium cepa*. Bulbs with a vigorous growth of young roots were treated for four hours and then placed in tap water which was frequently renewed. Aceto-orcein smear preparations of root tips were made immediately on removal from the veratrine solution and after four, eight, twelve and twenty-four hours of recovery in tap water.

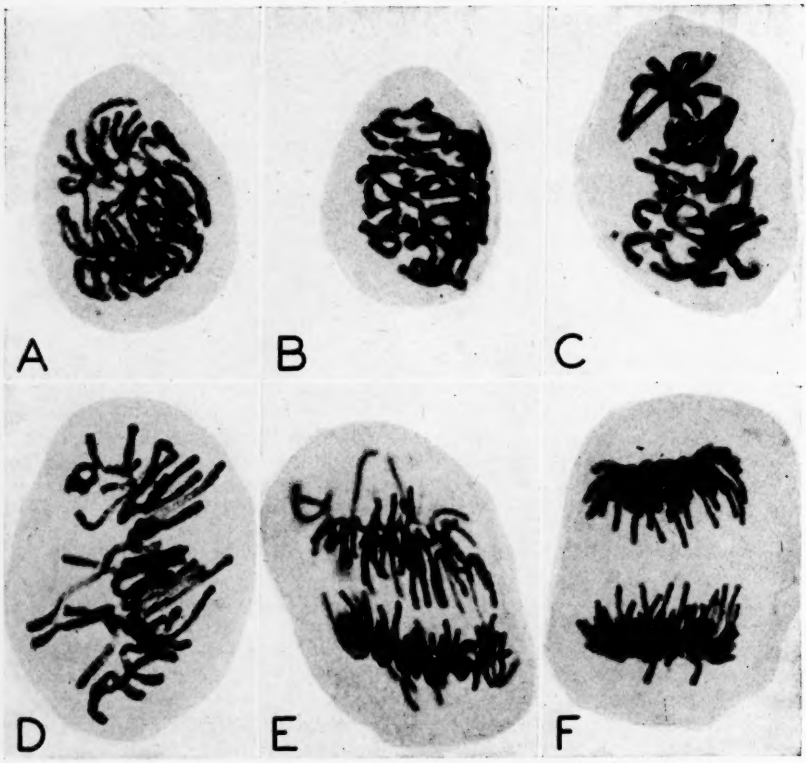
Cytological Effects

Cells treated with veratrine reveal the structural details of their chromosomes much more clearly than untreated material. Details of coiling and distinction of chromatids are especially evident at prophase (Figures 1*A* and 2*A*), and, in some cases, at other stages (Figure 1*D*). The division of the SA-region (spindle attachment) is greatly delayed at metaphase and the chromosomes continue to contract giving rise to diplo-chromosomes (Figure 1*B*, *C*, *D*, and *P*) similar to those formed under the influence of colchicine. Diplo-chromosomes resulting from veratrine treatment (Figure 1*B* and *D*) differ from those induced by colchicine (Figure 1*O*) in that the chromatid arms do not separate and diverge widely, forming the X-shaped diplos characteristic of colchicine treatment. This failure of chromatid arms to diverge may be due to an increase in the adhesive properties of the matrix, a possibility strengthened by the prevalence of false ("sticky") bridges (Figure 1*M* and *N*) at anaphase in veratrine treated material.

After a longer or shorter delay at metaphase, the spindle-attachment regions eventually divide (Figure 1*C* and *D*) and the reversion phase begins which will result in a tetraploid resting nucleus. This reversion phase follows one of two patterns depending on whether the veratrine treatment has completely or only partially suppressed the formation of the spindle. In the complete absence of a spindle the chromosomes, tetraploid in number, remain scattered throughout the cell (Figure 1*E*) and begin to take on the structure of anaphase and telophase chromosomes (Figure 1*F*), a nuclear membrane is formed and the polyploid cell thus established.

In many cases a partially functional spindle is formed and the chromosomes undergo an incipient anaphase separation (Figure 1*G*) into two groups which, however, do not converge at a focus in the absence of well defined spindle poles. This stage has been termed "pseudo-anaphase" and it is followed by a similarly abnormal telophase, "pseudo-telophase," in which the loosely grouped chromosomes lack the customary telophase polarization and have their chromosome arms extending in all directions (Figure 1*H*). These telophase groups undergo reversion resulting in two irregularly shaped nuclei with small protrusions (Figure 1*I*, *J* and *K*). The imperfect spindle is incapable of forming a cell plate and no cytokinesis follows.

*Aided by a grant from the Penrose Fund of the American Philosophical Society.



VERATRINE INDUCED TETRAPLOID CELLS

Figure 2

Prophase, metaphase and telophase stages of tetraploid mitosis are shown in material following recovery from effects of veratrine treatment. Cell division with the doubled chromosome number is apparently normal after effects of the drug have worn off. Magnification × 1000.

Some of these cells may remain binucleate, at least for some time, (Figure 1*I*), but in others the two nuclei fuse to form a tetraploid resting cell (Figure 1*J*, *K* and *L*).

With slightly higher concentrations (.15% and .2%) the chromosome matrix is affected resulting in many false chromosome bridges at pseudo-anaphase (Figure 1*M*). In some cases (Figure 1*N*) these lead to the formation of tetraploid resting nuclei. These slightly higher concentrations probably kill the cells which are in mitosis during the treatment as no polyploid divisions were found during the recovery of roots so treated.

There are then three ways in which tetraploidy can be established under veratrine treatment. The first method (Figure 1*A* to *F*) occurs in the complete absence of a spindle. The second method (Figure 1*G* to *L*) involves fusion of daughter nuclei following incomplete anaphase separation and failure of cell plate formation. The third method (Figure 1*M* and *N*) likewise involves an imperfect spindle but consists primarily in

the failure of anaphase separation due to "sticky" chromosome bridges.

Roots treated for four hours with a 0.1% solution show normal tetraploid divisions after eight hours' recovery in tap water (Figure 2*A* to *F*). Some division figures were found (Figure 2*D*) in which the full tetraploid complement of 32 chromosomes was not present, indicating that some of the original chromosomes were not included in the reversion nucleus.

Veratrine is effective in producing polyploidy within a much narrower range of treatment than colchicine,[1] and for this reason will probably prove to be a less useful tool to the plant breeder.

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THE Rh GENE AS A CAUSE OF MENTAL DEFICIENCY

THE so-called "Rhesus gene" of human blood was discovered by Landsteiner and Wiener in 1940. Purely an immunological oddity at first, this gene became a top-bracket "public enemy" when Levine showed that it was responsible for the deadly infant disease, erythroblastosis fetalis. By the end of 1942, Haldane was able to say* that "the effects of the *Rh-rh* difference certainly account for more human deaths than any other gene difference so far known, and very possibly for more than all other known gene differences together." The role played by the *Rh* gene as a cause of stillbirths and neonatal mortality was discussed by Levine in the February 1943 issue of this JOURNAL.

Since that time there have been further important developments. The growing series of *Rh* alleles now totals more than a half dozen. By using the antigen from the bearers of one of these alleles, it is possible to differentiate heterozygous (*Rh-rh*) and homozygous (*Rh-Rh*) individuals. Evidence of the part played by *Rh* incompatibility in transfusions has accumulated in the interval, and a committee of the Office of Scientific Research and Development is finding ways to avoid *Rh* complications in military medicine. These developments will be discussed later in the JOURNAL.

At a recent meeting of the American Association for Mental Deficiency (Philadelphia, May 11, 1944) a report was presented which suggests that the *Rh* gene may have still another role in developmental pathology. If these merely suggestive findings are confirmed, this strange blood incompatibility may prove to be responsible for a significant amount of feeblemindedness. The preliminary findings reported at that meeting by Dr. Herman Yannet and Miss Rose L. Lieberman are based on data obtained at the Southbury Training School at Southbury, Connecticut. A total of 109 visiting mothers cooperated by giving samples of their blood for *Rh* analysis. The children of these mothers were then classified according to *Rh* group and type of mental defect. Of these children, about half (53 out of 109) showed specific types of feeblemindedness. (Mongolians, spastic diplegia, birth trauma, etc.) The distribution of *Rh* positive and *Rh* negative mothers in these 53 cases was about average for the white population in the United States. Among the remaining 56 cases, classified as "undifferentiated mental deficiency," a different *Rh* distribution is found. Of the 56 mothers, 14 were *Rh* negative; more than twice the average for the general population. Furthermore, of the 14 negative mothers, 11 had *Rh* positive children. Neither of these deviations is statistically significant, though the excess of *Rh*+ children might be if an adequate control were available.

The normal distribution in the white population of the U. S. is: 85 per cent *Rh* positive, 15 per cent *Rh* negative, with the distribution of the genotypes as follows: 36.9 per cent *Rh-Rh*, 47.7 per cent *Rh-rh*, and 15.4 per cent *rh-rh*.*

*HALDANE, J. B. C. *Annals of Eugenics* 11:332-340. 1942.

With random matings in such a population, approximately 60 per cent of gametes are *Rh*, and 40 per cent are *rh*. It follows from this that conceptions in *Rh* negative women will average 60 per cent incompatible (*Rh-rh*), and 40 per cent compatible (*rh-rh*). Actually from this group of 14 *rh-rh* mothers, 78 per cent of the children are incompatible (*Rh-rh*).

The sample is so small that a larger array of mother-child comparisons might yield a different distribution. If there does prove to be a significant excess of *Rh*-positive children, it can be taken as a minimal measure of the influence of the *Rh* gene in inducing feeblemindedness. This is because it is known that the fetal and neonatal mortality among *Rh*-positive children of *Rh*-negative mothers is abnormally high. Thus our 60 per cent of incompatible *conceptions* might result in 55 or even 50 per cent of *living offspring*. Thus the excess of *survivors* who enter feebleminded institutions would be greater than 18 per cent. Depending on the extent of this early mortality, it might be found that 25, or possibly 30 per cent of undifferentiated mental deficiency could be attributed to the *Rh* gene.

The authors of this interesting report do not speculate as to the reason for the interrelationships between feeblemindedness and the *Rh* gene. One explanation which suggests itself is so simple and direct that it is probably wrong. The tissues of the central nervous system are notoriously susceptible to oxygen starvation. In asphyxiation, permanent injury to the brain takes place before other body tissues are damaged beyond the point of repair, and the danger of permanent injury to the brain through anoxemia during the birth process is a well recognized hazard of birth. The hemolytic reaction induced by the immune antibodies developed in the mother's blood, destroys the incompatible fetal red blood cells. The resulting prolonged oxygen deficiency at a time when embryonic growth processes are extremely active, might easily result in a permanent retardation of brain development. Recently Diamond reported that the antibody titre of some iso-immunized mothers does not begin to increase until quite late in gestation (usually after the eighth month) may leave an avenue of escape from this distaster to brain development. By frequent checking of the mother's blood and by inducing labor as soon as the antibody titre begins to increase, infants otherwise doomed to mental defect might in some cases be brought to birth without brain injury.

Kernicterus, one of the symptoms of erythroblastosis, is due to the injury of certain brain centers by excessive bile salts in the blood. In 1942 Levine suggested that spastic paralysis might also be traced to brain injury incident to *Rh* incompatabilitis. Thus Yannet's findings are in line with earlier observations.

The role of the *Rh* gene in the causation of feeblemindedness, and the possibility of prevention of its assumed morbid effect are, at the moment, compounded speculations. If the proportion of the assumed "*Rh*-feeblemindedness" were the same in the Southbury Training School as among all feebleminded, the totals for the whole country would be considerable. The number of feebleminded in the United States is conservatively estimated to be 1.5 to 2 million, though some authorities believe that this maximum could be doubled. Taking the lowest estimate, there would be three-quarters of a million "undifferentiated feebleminded" in the United States. If a third of these were defective because of *Rh* incompatibility, that would be a quarter of a million. If only a sixth owed their mental retardation to this cause, this would just about equal the total population of schools and institutions for mental defectives in the United States. Surely the prevention of so large an army of mental defectives is a goal abundantly worthwhile. No time should be lost in determining definitely whether Yannet and Lieberman have made a great discovery, or whether random deviations of proportions of *Rh* phenotypes in a small sample have played a grim statistical trick.—ROBERT COOK.

ALBINISM IN CATTLE*

W. E. PETERSEN, L. O. GILMORE AND J. B. FITCH, *Division of Dairy Husbandry,* AND L. M. WINTERS, *Division of Animal Husbandry, University of Minnesota*

THE occurrence of albinism in various breeds of cattle has been reported by a number of observers. Detlefson[3] reported a study of albinism in a Minnesota herd of Holstein origin in which the results of known matings indicated that the character was inherited as a simple Mendelian recessive. Some observations, however, were recorded to indicate that the inheritance might be otherwise.

For albinos of Holstein origin the character is complicated by the presence of the so-called "ghost" pattern. Cole, Van Lone and Johansson[2] reported studies of the same Minnesota herd and of a Wisconsin herd also of Holstein origin. They described "Albinotic" dilution in which the cattle are: ". . . at birth practically devoid of pigment but gradually, as the animals approach maturity, they develop some pigment in the iris of the eye and in the hair." The result of this particular dilution was described as a "ghost" pattern and is said to have occurred in all of the adult animals in both the Minnesota and the Wisconsin herds.

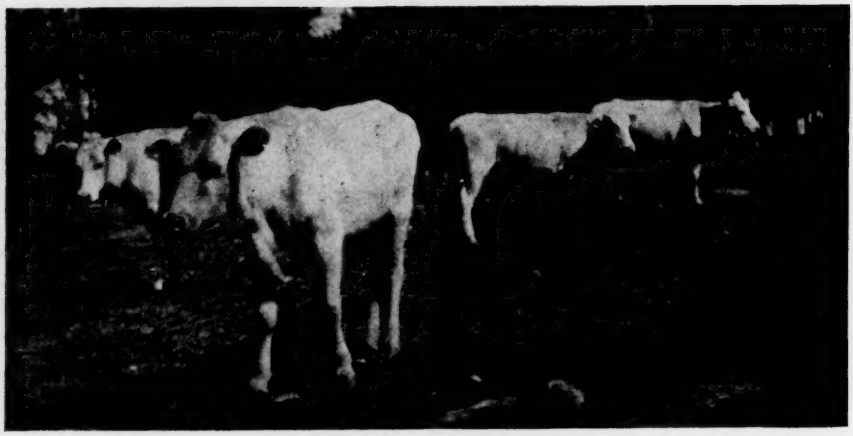
Albinism has been reported also for the Brown Swiss, Danish Red and Hereford breeds. Carstens, Mehner and Prüfer[1] reported observations on 22 albinos in a Brown Swiss herd in which the hair and the iris were pigmentless and definite photophobia was manifested. The authors were furnished with hair samples and pictures of albinos in a herd of Danish Red cattle located at Trolleminde by Hillerod, Denmark.[4] Careful inspection of the hair and the pictures revealed that the hair was devoid of pigment and that the "ghost" pattern was absent. One case of an albino male in a Hereford herd located in Montana has also been communicated to the authors.

The albinos forming the basis of this study are from two herds located in Kanabec County, Minnesota, one of which is the Kaslow herd about three miles southwest of Mora reported by Detlefsen, and by Cole, Van Lone and Johansson. Cattle were purchased from both herds and brought to the University Farm where recorded matings were made in an endeavor to establish the inherited nature of albinism and its relation to the "ghost" pattern. In addition to the breeding trials at the University Farm, as much history as possible from each of the two herds was obtained from the owners and their families in numerous visits to the farms and by correspondence. The essential parts of the histories have checked fairly consistently throughout the investigation. The more essential historical facts pertinent to this study are here given. The albinos produced in the Kaslow herd had been good reproducers and no albino calves were reported ever to have died. Inbreeding had been practiced since the appearance of the first albinos and the cattle were below normal size for Holsteins. A Guernsey sire used in 1934 was the first bull not of the Holstein breed used by Kaslow. Early in 1934 there were four albino cows (Figure 3) and one albino bull calf (later designated as *BA*1) in the herd. In the summer of 1934 two of the four females were purchased and taken to the University Farm for experimental studies. They became *A*1 and *A*4, respectively. Late in 1935 the albino male (*BA*1, Figure 4) and three normally marked aged cows reportedly out of albino dams were purchased and added to the University experimental herd.

After the original albinos were purchased another herd† in which albinism

*Scientific Journal Series, Paper No. 2141, Minnesota Agricultural Experiment Station.

†Acknowledgment is herewith made to Mr. K. W. Ingwaldson for his interest and help in obtaining these animals and data pertinent to the study.



ALBINOS OF THE KASLOW HERD

Figure 3

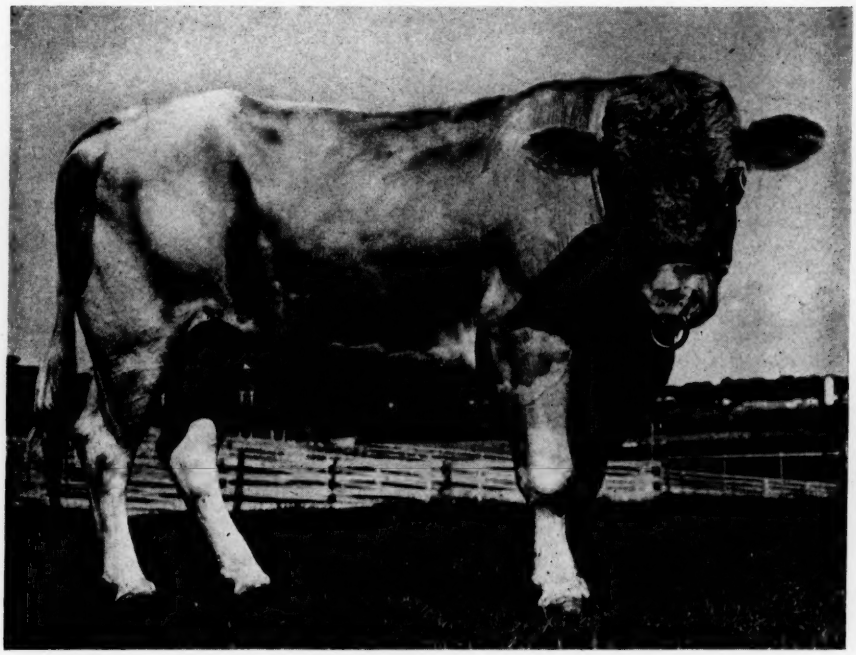
The Kaslow albinos originated about 1912-1914, when two white calves appeared in the herd from the mating of a "full-blooded" Holstein bull with grade cows. Since that time, by mating the albinos together, and by matings of albinos with "carriers," a herd of as many as 20 albinos has been maintained. They are extremely light-sensitive (note nearly-closed eyes) but are otherwise normal and produce as much milk as their pigmented herd-mates.

existed was brought to the attention of the authors. Two albino cows about 13 years old were traced to the herd of Frank Rezabek living eight miles northwest of Mora, which had the following history. In 1921 three albino calves, two heifers and a bull, were dropped on the newly acquired Rezabek farm. They were out of grade cows in a herd of reds, roans, and red and whites and were sired by a Holstein bull purchased at the South Saint Paul stockyards. The dam of one of the heifers, *A*3 (Figure 5) was a red roan. Both heifers were later mated with the albino half-brother and each produced a male albino calf at the first parturition. This bull was kept chained so as not to breed other females in the herd. He later was sold for slaughter. These five albinos were all that were ever produced in this herd. The two albino cows needed especially good pasture in order to keep in good flesh because of their sensitivity to outdoor conditions. They were bothered considerably by other members of the herd, presumably because of their inability to see well.

In 1929 *A*3, having been mated to a well-bred Guernsey bull, gave birth to a heifer that was blue-roan and white (Figure 6*B*). The condition for roaning can be traced to her maternal granddam but did not show in the dam because of the effect of albinism. The black hairs interspersed with the white in the roaned

TABLE I. Distribution of offspring for each of five types of matings.

Mating	Total	Normally marked	Albino	Ratio alb.:pig. Obtained	Ratio alb.:pig. Expected
albino × albino	7	0	7	0:7	0:7
albino × normal	16	16	0	16:0	16:0
albino × hybrid	10	4	6	4:6	5:5
hybrid × hybrid	2	1	1	1:1	1½:½ (3:1)
hybrid × normal	8	8	0	8:0	8:0
Total	43				



GHOST PATTERN

Figure 4

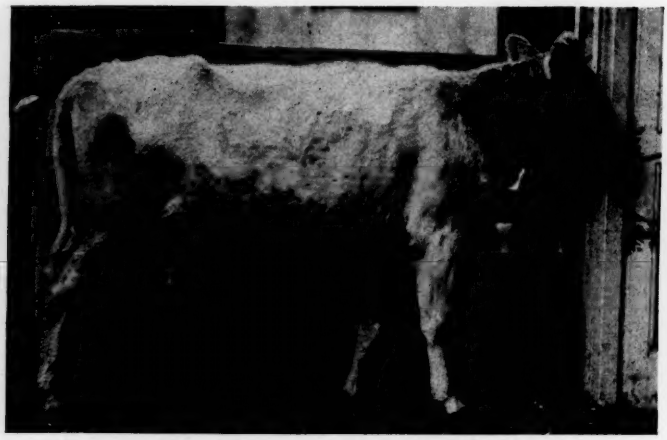
Purchased from the Kaslow herd, this albino bull, designated *BA*1 has a well defined "ghost pattern" which displays in two grades of white the markings typical of a Holstein bull. The pattern is not due to pigment in the hair, but to structural differences which alter the refractive index of the hairs. Thus in spite of the pattern, this animal may be classified as a true albino, not an "albinoid." (See Figures 7-8.)

areas are explained on the basis of the albino dam carrying the condition for black which is either epistatic or dominant to the reddish fawn of the Guernsey sire. In January, 1934, the same cow, *A*3, gave birth to a heifer that was nearly black (Figure 6*A*), after having been mated to a purebred Holstein sire of the genetic composition *Lwlw* according to the terminology of Ibsen.[6] The large amount of black on the daughter indicates that the albino dam carried at least one factor for little white (*Lw*), as well as the pigmented leg (*Pl*) factor.

The two females (*A*2 and *A*3) were good producers and were kept in the herd until late in 1934 at which time they were purchased for the University color experimental herd then consisting of the original two cows from the Kaslow herd.

From these purchased albinos and albino hybrids, matings were made to increase the number of albinos, to ascertain the nature of the inheritance of albinism and to determine the nature of the ghost pattern and its inheritance.

The results of 43 matings involving albinos and heterozygotes are given in Table I for each of the five types of crosses made. Where the numbers are large enough it will be noted that albinos were obtained in either exact or approximate ratio expected if albinism were a Mendelian recessive. In all seven cases where albinos were mated to albinos, the offspring were albinos. In the 10 albino $\times$ hybrid matings, six of the



A COMPLETE "GHOST PATTERN"

Figure 5

The albino cow *A3* exhibits no apparent "ghost pattern." When the hair was examined microscopically, it was found that all over the body it had the structural characteristics of the "dark" parts of the ghost pattern. In other words, she shows no "white" areas of the ghost pattern. She is the dam of an almost solid-colored calf by a normally-marked Holstein bull. Consequently she probably possesses factors for extending black over all or nearly all of the body. The breeder who raised her believes that her dam was a red roan.

offspring were albinos and four were normally marked. For the small number of matings this approximates the ratio of 1:1 that would be expected if albinism were due to a simple Mendelian recessive. One of the two hybrid × hybrid matings resulted in an albino when one out of four would be the expected ratio with larger numbers. In not a single case of 24 matings of either albino or albino hybrid with normal animals was an albino produced. This, too, conforms to the expected results. Furthermore, the production of an albino from two normally marked hybrid parents may be taken as crucial evidence that albinism is inherited as a Mendelian recessive.

The "Ghost" Pattern

While the general character of albinism can thus be concluded to be due to a simple Mendelian recessive, the inheritance of albinism in cattle of Holstein origin is complicated by a "ghost" pattern. A total of 24 albinos, 11 females and 13 males, were studied for the "ghost" pattern. Observations begun at birth on 15 of these lasted until they reached varying ages up to maturity. In no instance has the "ghost" pattern been observed at birth or in the young calf before three months of age. This is in agreement with the observations of Cole, Van Lone and Johansson.[2]

Of the 13 albino males, the "ghost" pattern has been observed on 12 (all that were old enough for the character to have developed). One male died shortly after birth. Of the eight females over one year of age that have been studied, the "ghost" pattern has been observed on four. From Figures 4 and 9, it will be noted that the "ghost" pattern conforms essentially to the pigmented area of the Holstein pattern. This conformity undoubtedly led Cole, Van Lone and Johansson to postulate that it was due to a dilution of the pigment.

In order to obtain information as to the reason for the differentiation between "ghost" and white areas, the hair was clipped short, the skin was shaved across the lines of demarcation and hairs from both areas were examined microscopically. In all cases, when the hair was

TWO DAUGHTERS OF AN ALBINO COW BY PIGMENTED BULLS

Figure 6

The cow at the left is an almost solid-colored daughter of *A3* (Figure 5), sired by a Holstein bull, heterozygous for the extended pigmentation gene (*LW-lw*). The cow at the right is a spotted blue roan, daughter of *A3* by a Guernsey bull. The roaning traced to *A3*'s mother but did not show in *A3* herself because of albinism.

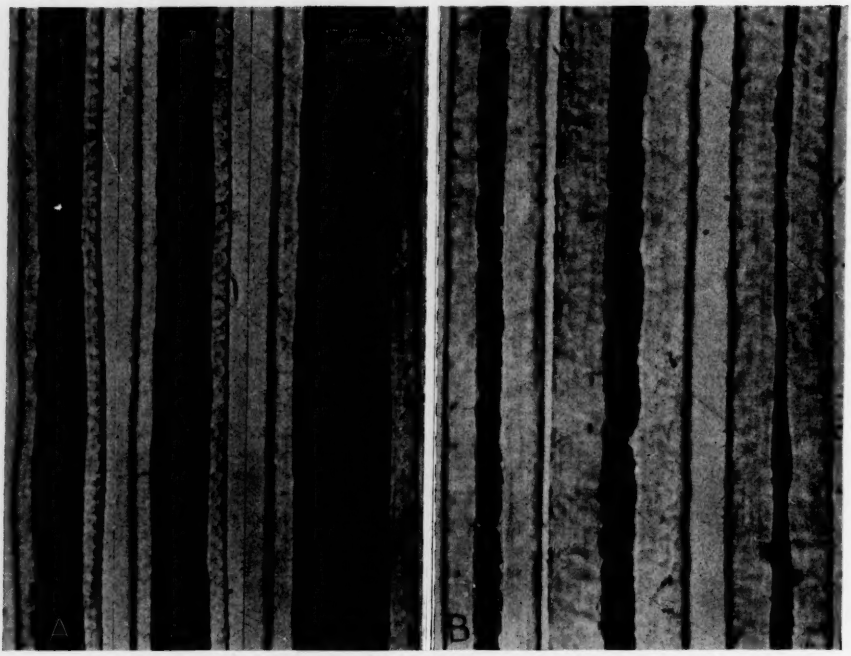
clipped short the "ghost" pattern became more distinct. When strips were shaved across the lines of demarcation no difference could be detected in the appearance of the skin in the two areas.

Microscopic examination of the hair of five males and three females brought out several differences in the hair characteristics of the two areas. Hair from the two areas differed in the amount of "apparent" pigment granules in the hair; the diameter of the hair shaft; the relative thickness of the cortex and diameter of the medulla. There was also a measurable sex-difference in hair dimensions.

The difference between the "ghost" and white areas has been reported as due to differences in the amount of pigment particles in the hair. Microscopic examination confirmed this only in part. First attention was directed to the difference in the so-called pigment particles formed in the hair of the albinos used in these studies and in normally pigmented hair. The particles in albino hair, besides being much more dispersed, are located peripherally in the cortex instead of being uniformly dispersed therein. The distribution and character of the particles in albino hair resemble more the rust spots observed on the stems of grain. While in most cases the hair on the "ghost" area had more of these apparent pigment particles than that of the white area; in the males these pigment particles were found in hair from both areas. *In one female, A30, having a very distinct "ghost" pattern, no pigment particles were found in the hair from either area.*

As a rule the hair from the "ghost" area had a greater diameter of the hair shaft. The greatest difference between the hair of the two areas, however, was in the relative thickness of the cortex and medulla. The sex difference was also significant. In all females the hair from the white area had unusually large medullas with relatively little cortex (Figure 7*A*) while in the "ghost" areas the relative proportion of these two hair structures was that of normal hair (Figure 7*B*). In the males the hair from the white areas had the appearance of that from the "ghost" area of the female (Figure 8*A*) while that from the "ghost" area with few exceptions had no medulla. When medullas appeared in hair from the "ghost" area they were small and never extended throughout the length of the hair shaft.

The darker appearance of the "ghost" pattern, therefore, probably is not due to the pigmentation of the hair but to a greater absorption of light. A logical



HAIRS FROM "GHOST PATTERN" FEMALE

Figure 7

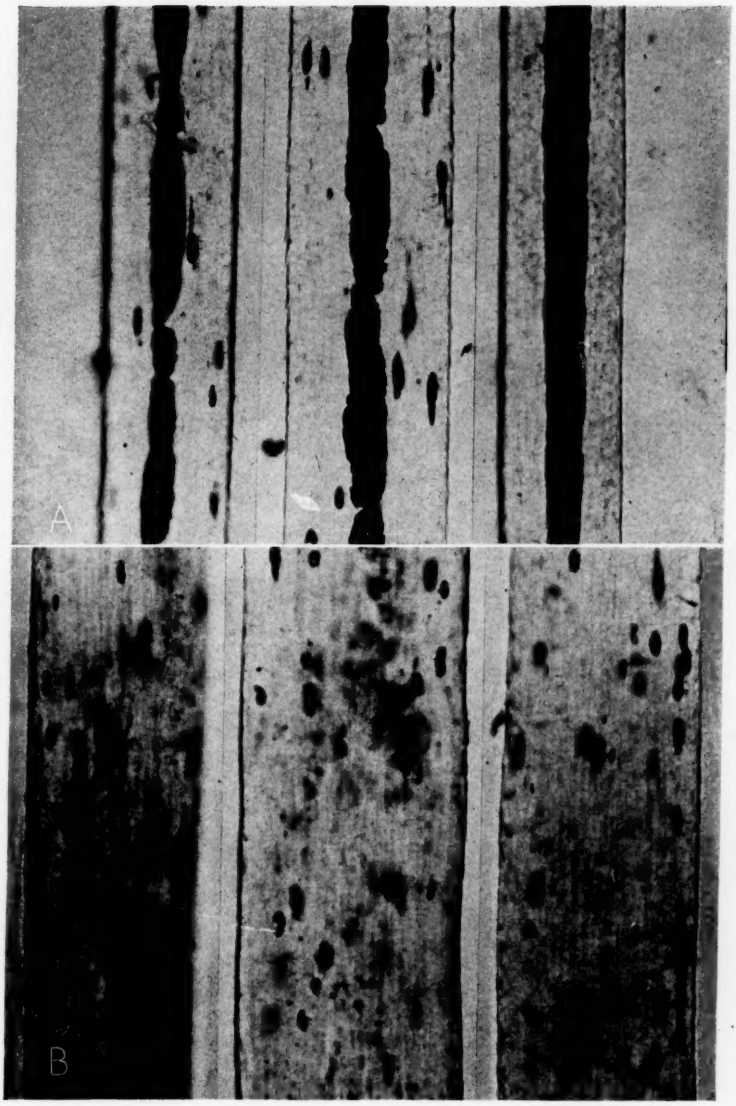
A shows hairs from the "white" area, compared with hairs from a "ghost pattern" area on the same animal (*B*). The "white" hairs are smaller than those from the "ghost pattern" area and they differ in the relative thickness of cortex (light "skin") and medulla (dark "core"). Only traces of pigment granules were present in any of the hairs. The apparently darker color of the "ghost pattern" hairs is due to the lesser refractive properties of the hairs with small medullas.

explanation for the effect is that the cortex-medulla interface acts as a reflector of light, some of which is absorbed by the cortex. Consequently, the larger the medulla and the smaller the cortex the more light that will be reflected and the whiter the appearance of the hair.

The albinos possessing "ghost" patterns differ from the normally pigmented animals in two particulars, each of which would appear to require a separate genetic factor. Pigment is essentially absent from the hair. Also the structure of the hair on the "ghost" areas is significantly altered from that of the normal in which no essential difference between the relative size of the cortex and medulla has been observed in hairs from pigmented and non-pigmented areas. If the "ghost" pattern appeared on all cattle with white spotting inheritance it could be postulated logically that the hair abnormality in some way prevented pigment formation. But inasmuch as several albinos with white spotting inheritance did not possess the "ghost" pattern such a postulate is untenable.

There is reason to suspect that the "ghost" pattern is present only in albinos carrying the factor for black (*B*) either in the heterozygous or homozygous condition. While the evidence for the association of *B* with the development of the ghost pattern is not conclusive the following facts support such a view.

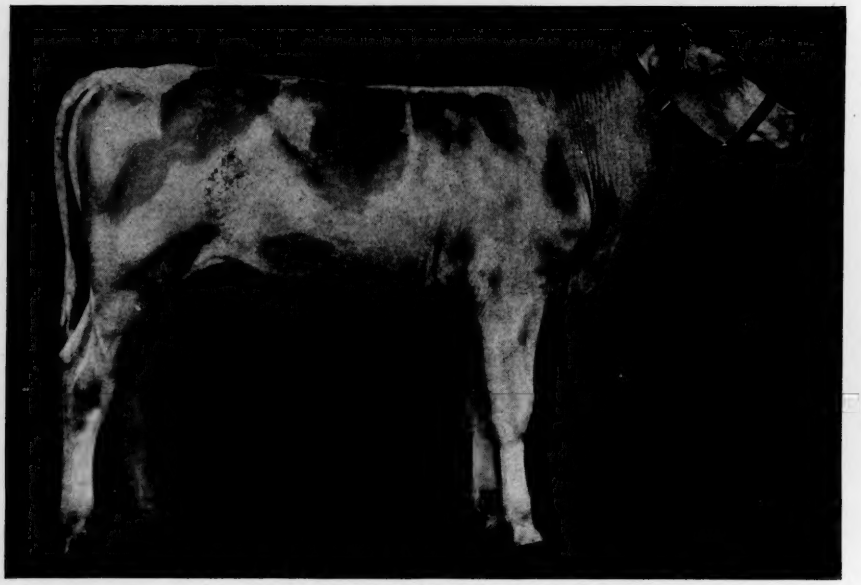
1. For each of the three females (*A1, A12* and *A55*) on which "ghost" patterns were not discernable, there is evi-



HAIRS FROM MALE ALBINO

Figure 8

A shows hairs from the "white" area of male *BA*12. *B* shows hairs from the "ghost pattern" area of the same animal. In the male, the "ghost pattern" hairs have no medulla, in contrast to the medullated hairs of the white areas. Occasionally a partially medullated hair would be found in the ghost area, but this small medullary island never extended throughout the length of the hair shaft. Apparently the interface between the medulla and cortex acts as a reflecting surface, so that there is a difference in absorption and reflection of light due to this optical property rather than to the presence of pigment.

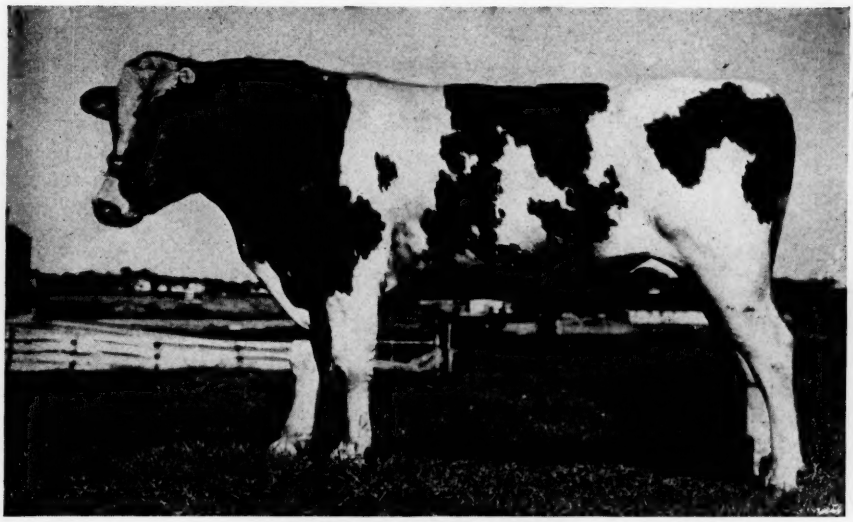


PATTERN OF CLIPPED MALE
Figure 9

Even when the hair is very short, the ghost pattern is distinct in spite of the fact that when an area is shaved so that a dividing line crosses it, the skin shows no difference in pigmentation in the "white" and "colored" areas.

dence that they were recessive for black. The cow, *A1*, was out of an albino, the history of which is rather obscure, and the sire was said to be a registered Holstein although this assertion cannot be verified. That *A1* carries at least one recessive of black, (*b*), has been established by the production of a reddish fawn and white calf (*BA2*, Figure 10) when mated to a pure-bred Guernsey male. *A12* is out of *A1* and sired by *BA2*, the reddish fawn and white son of *A1*. Assuming *A1* to be homozygous for the recessive of black (*bb*) *A12* also must be so. Proof that *A12* carries the recessive of black at least in heterozygous form was obtained in mating her to her reddish fawn and white sire (*BA2*) which resulted in a red and white calf. There is an even chance that *A55* was *bb*. Her dam was red and white (*bb*) and her sire was *Bb*.

2. For each of the four albino females (*A2, A4, A30* and *A53*) that showed the ghost pattern and the one (*A3*) whose hair indicates the presence of the pattern, there is the following evidence that they carried the factor for black (*B*). *A2* was sired by a black and white grade Holstein bull. *A3* (Figure 5) was out of a red roan dam and sired by the same bull as *A2*. That she carried *B* is further evidenced by her producing a fetus with black spots, from a mating with an Ayrshire bull, and by producing a blue roan calf (Figure 6*B*) by a Guernsey bull. The factor for the black skin in the first case and the black hairs in the second case must be *B* either in homozygous or heterozygous condition. The factor for roaning undoubtedly comes from the red roan Shorthorn maternal grandam. When mated to a Holstein bull of the composition *Lwlw, A3* gave birth to an almost solid black calf (Figure 6*A*) indicating that she carried factors extending black over a large part of the body and also the pigmented leg



GUERNSEY-ALBINO HYBRID
Figure 10

BA2 is reddish fawn and white. He has a typical Guernsey pattern. His dam, *A*1, must carry at least one recessive black gene.

factor (*Pl*), both of which account for an apparent lack of a "ghost" pattern. Microscopic examination of the hair indicates it to be of the "ghost" pattern type over the entire body.

A4 was out of an albino of unknown ancestry. She was sired by a purebred Holstein bull from which she may have inherited *B*. Proof that she carried *B* is provided by a brown and white offspring sired by a Guernsey bull. There is an even chance that *A30* is heterozygous for *B* as her sire was *bb* and her dam *Bb*. There is at least a three to one chance that *A53* carries *B* as her sire was *Bb* and her dam black and white (*BB* or *Bb*).

3. For the twelve males on which the "ghost' pattern has been observed, three of them have been proved to carry *B* by siring black and white offspring from Ayrshire matings. Of those remaining, the minimum chances of their carrying *B* is three to one for one and at least three to one for three of them. The chances are one to one for one and at least one to one for three others.

4. The pictures of the Danish Red albinos together with examination of hair from them revealed no evidence of either a "ghost" pattern or hair abnormality. Danish Red cattle are *bb*.

5. Absence of the "ghost" pattern and hair abnormality in the Danish Red and several of the Minnesota albinos is evidence to rule out the color pattern genes *per se* as being responsible for the hair abnormality. The Danish Reds are solid colored (*SS*) and all of the Minnesota ablinos possessed recessive white spotting (*ss*) or at least there is no evidence in their genetic history to indicate the contrary. For two of the albino females without "ghost" patterns (*A1* and *A12*) there is proof that they carried recessive white spotting at least in heterozygous condition. Each of them produced one spotted offspring. For the third case (*A55*) there is at least a one to one chance that she was homozygous for recessive white spotting. Her dam was spotted (*ss*) and her sire got only spotted offspring when mated to spotted cows. Therefore, he could have been *Ss* or *ss*. Because both *A12* and *A55* are

inbred descendents of *A1* the assumption that all are homozygous for recessive white spotting gains credence.

While albinism may be modified by the presence of *B* in the formation of a "ghost" pattern, other factors for color and at least several factors affecting color pattern may also be present without any apparent effect. The evidence for the presence of red (*bb*) in albinos has been presented above. Factors for either dilution or intensity of color has been shown to be present. Proof of this lies in the production of a brown and white calf from *A4* when mated with a Guernsey bull, and a red and white heifer from the mating of a reddish fawn bull, *BA2*, and the albino *A12*. According to Ibsen, Holsteins carry the dominant intensity factor (*II*), Guernseys being *ii*.

Attention is directed, in previous reference, to evidence that albinos may carry the following color pattern factors: Self (*SS*); recessive white spotting (*ss*); recessive white spotting modifiers (*Lwlw*); and pigmented leg (*Pl*). Gilmore, Petersen and Fitch[5] have reported three albino bulls of Holstein origin carrying a dominant modifier of the Ayrshire pattern.

On the basis of these observations it is apparent that albinos may possess factors for color and color patterns but lack a basic factor for pigment formation. While all hair pigment is assumed to be due to melanin, according to Petersen and Sandstrom[7] the different colors observed in cattle are due to differences in the size and number of the pigment granules in the hair. It is well known that melanin is formed from the action of the enzyme tyrosinase which is present in the pigmented hair areas in normally pigmented animals. Using C^a as the symbol for this factor, normal Holsteins have the genetic formula for color pattern of:

LwLw
C^uC^a *BB ss Lwlw plpl*
lwlw

An albino with a "ghost" pattern is given the following color formula:

LwLw PlPl
c^uc^a *BB ss Lwlw Plpl*
Bb lwlw plpl

An albino without a "ghost" pattern is given the following color formula:

SS LwLw PlPl
c^uc^a *bb Ss Lwlw Plpl*
ss lwlw plpl

Summary and Conclusions

1. The results of 43 matings involving albino and heterozygous albino matings and crosses of these with normal Holsteins, Guernseys and Ayrshires are reported. In all cases albinism was inherited as a simple Mendelian recessive.

2. "Ghost" patterns were observed on at least five out of eight females six months old or older. Microscopic examination of the hair indicated a fifth to be thus classed. All of twelve males old enough, showed a "ghost" pattern.

3. The "ghost" pattern is not present at birth but develops during the latter part of the first six months.

4. The "ghost" pattern is not due so much to pigmentation of the hair as to a hair structural abnormality.

5. The darker appearance of the ghost pattern area probably is due to a greater absorption of light because of the hair structure.

6. On the basis of the information at hand it is proposed that the "ghost" pattern is associated with the factor for black (*B*).

7. It is demonstrated that albinos may carry *B, bb, SS, ss, Lwlw, Plpl,* and the dominant modifier of the Ayrshire type of recessive white spotting that is found in Holsteins.

8. It is proposed that albinism is due to the lack of inheritance factors conditioning the presence of the enzyme tyrosinase.

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A NEW CASE OF TYPICAL BRACHYDACTYLY

HUGO ILTIS
The Mendel Museum, Fredericksburg, Va.

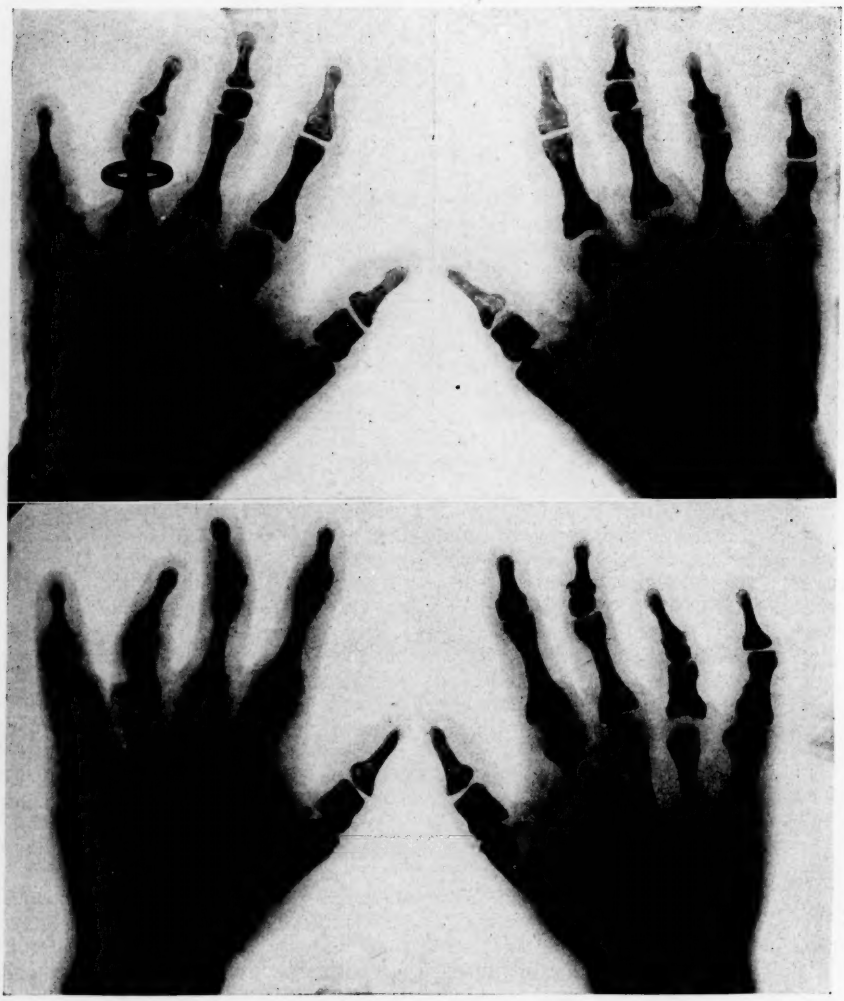
SINCE the classical reports by Farabee[12] and Drinkwater[7] many cases of so-called brachydactyly have been published. Almost none of the later cases have been altogether typical and as well defined as were those first reported. Typical brachydactyly characterized by short fingers and toes with two joints instead of three, due to ankylosis of the rudimentary middle phalanx to the distal one, seems to be rather rare and the description of a new case is therefore justified.

The proband in my case is a young lady of otherwise normal appearance and intelligence but of small stature and with short broad hands showing typical brachydactyly with two joints instead of three in all fingers. She informed me that her feet show the same condition and that this peculiarity is inherited from her mother and grandmother. Sometime later I obtained the pedigree shown below.

Since the family lives several hundred miles north of Fredericksburg, a comparative anthropological examination was out of the question for the time being. I am greatly indebted to my friend Dr. Ramsey Spillman of New York, for taking the X-ray photos of the hands of both mother and daughter. The pictures show the conformity of our case with that described by Drinkwater. The middle phalanx of the fingers is either visible as a rudimentary cubical bone (middle finger of daughter, middle and ringfinger of mother) or it is ankylosed with the third phalanx, which therefore differs in shape from the normal distal phalanx. Its cubical basal portion representing the rudimentary middle phalanx has become ankylosed to the pyramidal terminal portion representing the distal phalanx. Our x-ray reemphasizes Drinkwater's point that there is no real absence of the second phalanx but merely a rudimentary condition and that at a certain stage of development there is an union between the third phalanx and the rudimentary second. Drinkwater's view that typical brachydactyly may be regarded as a homeotic variation of the digits into likeness of the pollux, a virtual "thumbification" of the fingers, seems to give an adequate explanation.

There are some differences between the hands of mother and daughter. The latter's hands seem to be somewhat more reduced and more typically brachydactyl than are the mother's. This is especially evident in a comparison of the ringfingers, where in the daughter's hands not only is there complete ankylosis between the third and second phalanges but the phalanx also is extremely short. In the mother's left hand the second phalanx, although rudimentary, is still present as a separate ossification. In her right hand we have a very interesting intermediate stage, with the bones just ankylosed, but with the second phalanx still recognizable as a separate cubical appendix to the epiphysis of the terminal phalanx.

In spite of these and other small differences the similarity between the hands and fingers of mother and daughter is surprisingly close, and a comparison of them offers a dramatic illustration of the power of heredity. In both mother and daughter, the terminal phalanx of the ring finger shows a distinct inclination (valgus deviation) towards the middle finger. The middle fingers of both hands are the last ones to undergo the final junction between the rudimentary diaphysis of the middle phalanx and the epiphysis of the terminal phalanx. In both cases the little and the index fingers show the brachydactyl character most distinctly, consisting only of the two phalanges like the thumb.

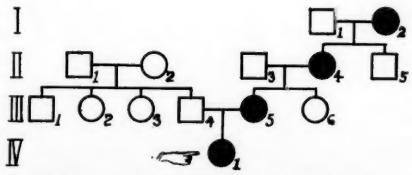


BRACHYDACTYLOUS HANDS OF MOTHER (ABOVE) AND DAUGHTER

Figure 11

The normal hand has three finger-bones (phalanges) of approximately equal length, but these have in most fingers two phalanges, one of which is made of two fused together. The bones of brachydactyl fingers thus resemble thumbs. The feet are similarly affected, but no other deviations from the normal were noted elsewhere in the body.

The thumbs of both hands are also very similar, showing a characteristic short and broad proximal and a rather long and slender distal phalanx. A common feature of the hands of both mother and daughter is also the generally frail appearance of phalanges and metacarpals. The diaphysis is abnormally thin and slender, while the epiphysis is relatively broad thus giving to the phalanx an hourglass-like contour. In both hands we may further recognize some sesamoid



FOUR GENERATIONS OF SHORT FINGERS IN THE FEMALE LINE

Figure 12

The hands of III-5 and IV-1 are shown in Figure 11. The condition of the hands of the two affected individuals in the preceding generations is based on family tradition. The fact that only females are affected in this pedigree is assumed to be due to chance, for the numbers are too small to justify an hypothesis that some other mechanism is involved.

structures not only in the metacarpal joints of the thumbs but also in those of some of the other fingers (see Figure 11).

Not only the force of heredity is well illustrated by the two pictures but also the phenomenon of dominance. The father of the propositus has normal hands and feet and therefore must have transmitted to his daughter the allele for normal development. If anything, the character of brachydactyly is even more strongly expressed in the daughter than in the mother who assumedly is also heterozygous. A striking resemblance may be noted between the hands of the daughter in our case and the hands of a brachydactylous woman, aged 32, from Drinkwater's unpublished photographs shown by Bateson[1] (page 213). There also a separate ossification can be seen in digit III between the first and third phalanges. Even the inclination of the terminal phalanx of the ring finger toward the middle finger, although less obvious, is present in Drinkwater's photograph.

The papers of Farabee and Drinkwater proved brachydactyly to be conditioned by a single dominant factor and with a simple monohybrid ratio in heterozygous matings. Farabee derived his conclusions from a pedigree covering five generations and including 69 individuals, 36 of whom were affected and 33 normal. In the pedigree shown in Drinkwater's first paper there were 75 descendants of abnormal parents in six generations, 39 of them abnormal and 36 normal. Both authors emphasized the fecundity of the families as a whole, the affected being even more prolific than the normal.

The pedigree of our case, however, shows within four generations only five children of abnormal parents, three of them abnormal, two normal. The fertility is rather below average. The pedigree fits well with the assumption that the trait is dependent upon a single dominant factor. I do not want to build up any new hypothesis upon the fact that all affected are of female sex. Farabee's and Drinkwater's results are convincing, and the numbers here reported are too small to exclude the possibility that the limitation of the trait to females is due to chance.

There seems to be no connection between this family and the American family described by Farabee nor to Drinkwater's two English families of which the second was descended from Farabee's American family. Considering the specific characteristics and the surprising similarity in the skeleton of the brachydactyl hands of persons from Farabee's, Drinkwater's and from our pedigree, it might be questioned that so specific a variation could have arisen independently in three unrelated families. Parallel mutations are well known to geneticists, and to quote Bateson "to those who have experience of variations and who know how large and well defined discontinuous variations may frequently be, it will not seem much more difficult to conceive of the repetition of the variation than of its first occurrence."[1]

A Classification of Finger Defects

Since the term *Brachydactyly* so well defined by Farabee and by Drinkwater's first papers has very often been applied to various quite different malformations it seems desirable to define at least some of the important abnormalities which have been confounded with brachydactyly. A classification has been tried by Pol.[20] An excellent summary has been

given by Gates.[12] The term *true or typical brachydactyly* should be applied only to cases where all or nearly all of the fingers and toes are short with two joints instead of three, due to ankylosis of the rudimentary middle phalanx to the distal one. It is characteristic of true brachydactyly that hands and feet, although abnormal, do not look pathological or crippled. In addition to the cases of American and English families reported by Farabee and Drinkwater, there are two cases, a German and a French one quoted by Lewis.[18] Then there is one referred to by Gilmore,[15] another by Walter (without anatomical details) and finally our case. There are several other earlier records without anatomical and genetical statements.

Minor Brachydactyly, as defined by Drinkwater,[8] is characterized by short fingers and toes due only to an abnormal shortening of the middle phalanx. With minor brachydactyly we may perhaps include cases where only some or one of the fingers are shortened as is the case of *Short Thumbs.*[2,17,19]

Symphalangy (Ankylosis, Orthodactyly) was defined by Cushing[6] to be the hereditary ankylosis of the phalanges without abnormal shortening, resulting in what is called "stiff fingers." The ankylosis may take place either between the proximal or the distal phalangeal joints. This is a relatively common abnormality and has been described by Cole[4], Cushing,[6] and Drinkwater,[10] and many others.

Clinodactyly, an abnormal valgus deviation of whole fingers or toes or of single phalanges, appears sometimes in connection with brachydactyly, as in our case. It is an independent variation and must not be confounded with brachydactyly. Described by Pol,[20] Cohn and Ravin,[3] and many others.

Short Metacarpals or Metatarsals may give to hands and feet an appearance simliar to brachydactyly, but these are distinct variations and have to be viewed separately. (Gillette,[14], Steggerda,[21] and others.)

Hypophalangy or absence of the distal phalanges and therefore of the nails, is a more disfiguring malformation easily distinguished from brachydactyly. (Craggle and Drinkwater,[5] Gilmore,[15] and others.)

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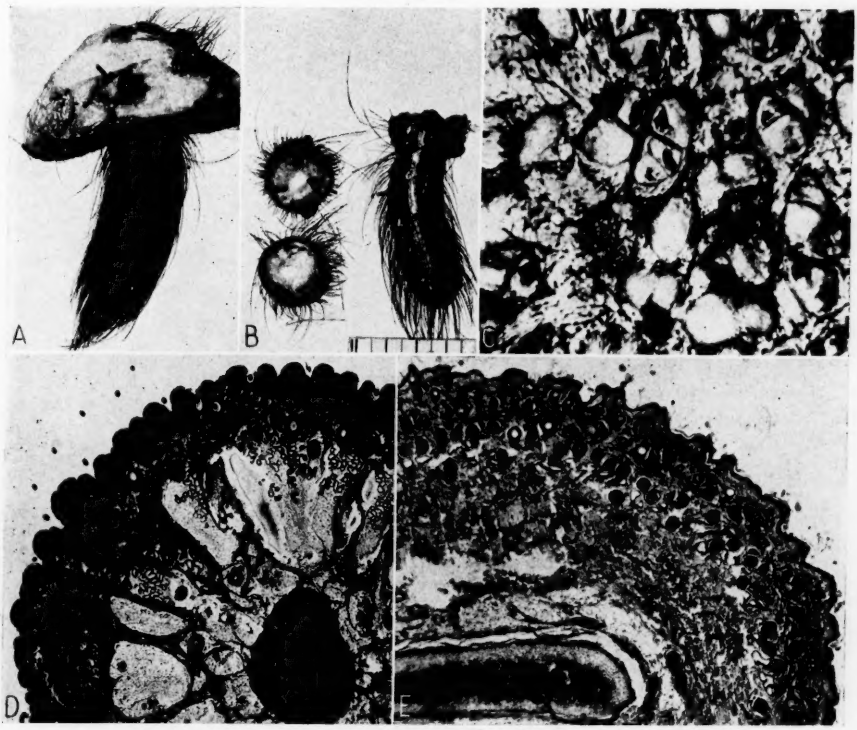
INHERITANCE AND HISTOLOGY OF WATTLES IN SWINE

E. ROBERTS AND C. C. MORRILL
University of Illinois



STRUCTURAL DETAILS OF SWINE AND GOAT WATTLES

Figure 13

A-D show details of the structure of swine wattles; *E* is a section of a goat wattle showing similar structure. *A* shows a wattle-like appendage with a knob-like head on the cartilaginous core (shown by arrow). *B* shows a longitudinal section with the cartilaginous core indicated by arrows (*A* and *B* approximately ×0.6 natural size). *C* shows a cross-section of the core showing the fibrous character of the cartilage (×316). *D* is a cross-section of a swine's wattle showing the fibrous connective tissue, the cartilaginous care, adipose tissue, and the skin structures (×7.4). A similar cross-section of a goat's wattle is shown at *E* (×19.7). The structure is generally like that of the pig's wattle.

THE occurrence of wattles in swine has been recorded by several writers, Eudes-Deslongchamps,[7] Richardson,[10] Darwin,[4] Bateson,[2] Kronacher[8] and Cook.[3] A case has come to our attention recently in which a grade Hampshire boar with wattles had sired several litters from sows normal in respect to the wattled condition. These pigs were seen in the summer when three to four months of age. Mortality since farrowing had been high but the farmer reported that about half the pigs had wattles as shown in Figure 14, which suggested a dominance of the character and an heterozygous condition of the boar. The same

WHAT PURPOSE WATTLES?

Figure 14

Wattles in birds are part of the assumedly decorative secondary sexual trappings of the male. In swine these curious organs, with a rather complicated structure appear to serve no useful purpose whatever in swine economy. They are inherited as a Mendelian dominant character found in many breeds and strains widely separated over the face of the earth.

wattled boar had been used by another farmer to produce fall litters. Arrangements were made with D. J. Witt, a teacher of Vocational Agriculture, to obtain records on the litters of this herd after the fall farrowing. Eighty-four pigs were produced by nine normal sows. A few of the 84 were killed at farrowing and some others died before inspection for wattles was made. Of 65 remaining pigs, 29 had wattles. Assuming the absence of differential mortality among wattled and non-wattled pigs the 65 which were examined would constitute a random sample. If the wattled condition is due to a single gene difference, a 1:1 ratio of wattled to non-wattled pigs would be expected among the progeny of an heterozygous boar (*Ww*) and normal sows (*ww*). The deviation between the theoretical and observed results is 3.5. X^2 is .75 which indicates a good fit. Kronacher[8] concluded that in swine, wattles are inherited as a simple dominant. Wattles in goats are reported by Lush[9] to be inherited in the same manner and Asdell and Smith[1] conclude that the hypothesis that the appearance of tassels or wattles in goats is due to a single dominant factor appears to hold good in the majority of cases.

Eudes-Deslongchamps[7] reported unilateral or bilateral appendages attached to the jaws of Normandy pigs and described them as cylindrical, covered with bristles, and with a pencil or tuft of bristles rising out of a sinus on one side. He also mentioned the presence of a cartilaginous center and two small longitudinal muscles. Additional histological studies have also been reported by Ellenberger and Guenther[5] and Ellenberger and Scheunert.[6]

The wattles which we have observed are also teat-like appendages, each having a cartilaginous core (Figure 13*A*). The core, which apparently is fibrocartilage (Figure 13*B*), has a roughened, knob-like proximal end embedded in the subcutaneous tissue of the jaw and extends, shaft-like, down the center of the appendage through almost its entire length. The cartilage itself is closely invested by dense, fibrous connective tissue from which connective tissue bands extend more or less radially, reaching the skin after some branching (Figure 13*C*). The spaces between the connective tissue bands are filled with adipose tissue. Muscle tissue, as described by Eudes-Deslongchamps in Normandy pigs, is not observed. The skin is normal for the species and completely covers the appendage.

Sections from the wattle of a goat (Figure 13*E*), made for comparative purposes, show that structure to be histologically similar to that in swine, the chief points of difference being its relatively lower content of adipose tissue, and the shape of the cartilaginous core. These differences are evident when Figures 13*D* and *E* are compared.

Summary

1. Wattles in swine appear to be due to a single dominant gene.

2. The wattles occur in pairs, each with a core of fibrocartilage. It is surrounded by dense, fibrous connective tissue, with connective tissue bands extending to the skin. Adipose tissue fills the spaces between the connective tissue bands. The wattle is covered by normal skin.

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ARTIFICIAL INSEMINATION IN MAN

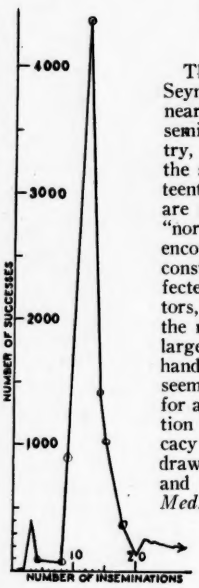
We have commented in the JOURNAL before on the espousal of human artificial insemination as "eugenics" by Drs. Seymour and Koerner. The difficulties of making artificial insemination a genuinely eugenic process were emphasized while the whole procedure remains shrouded in impenetrable secrecy. The method might offer outstanding possibilities in sire selection, but as far as the record shows, "eugenic sire selection" seems to mean larger progenies for football stars, a consummation offering no particular improvement over the traditional iceman (who more than once has risen to the gridiron from the kitchen door).

In 1941, Seymour and Koerner published a remarkable article* summarizing recent results of artificial insemination in the United States. This survey, based on a questionnaire sent to 30,000 physicians (of whom 22,358 failed to reply) disclosed a total of 9,489 women who had "achieved at least one pregnancy by this method."

Even a cursory examination of the data brings to light curious inconformities. Item: There was a marked and unexplained excess of males (5,676 ♂ : 3,813 ♀). Item: In nearly ten thousand births, not a single case of twins was mentioned. Item: A chart showing the number of inseminations required to initiate conception. This indicated that hardly ever was success achieved before the seventh insemination; that there was a sharply rising curve to the twelfth. Nearly half (4,312) successes were reported on the twelfth try. Hardly ever was success achieved after the fifteenth try, in spite of which the authors advised continuation of the repeated injections far beyond this optimum. Item: The totals given in the tables did not check when added across and up and down. Item: Pregnancy wastage was reported as under three per cent, as compared with six to eighteen per cent in the general population.

These and other discrepancies are called to attention by Dr. Clair E. Fulsom in the *American Journal of Obstetrics and Gynecology* for June, 1943 (Pages 519 to 527). Altogether a skeptical attitude seems justified regarding the statistical validity of the results reported. In view of these discrepancies, it seems superfluous to attempt to account for the lack of twins or for the excess of male births reported in this study. It is concluded by Dr. Fulsom that artificial insemination has a limited utility in medical practice and that it is not a solution of the problem of human sterility. The legal complications are also discussed.

Dr. Seymour and Dr. Koerner are the moving spirits in the rather ambitiously titled "National Foundation for the Eugenic Alleviation of Sterility." It is unfortunate that again the word "eugenics" appears in a misleading context, wherein its primary meaning will be further confused in the popular mind. R. C.



LEPTOKURTIC PHALLACY—?

Figure 15

The data presented by Seymour and Koerner show nearly half the successful inseminations on the twelfth try, with very few before the sixth or after the fourteenth. (Leptokurtic curves are more "peaked" than a "normal curve." They are encountered when a very constant character, little affected by environmental factors, is plotted — such as the number of fingers on a large sample of human hands.) Gynecologists seem at a loss to account for a physiological explanation for this peculiar efficacy of the twelfth try. Redrawn to scale from chart and data in *Jour. Amer. Med. Assoc.* 116:2747. 1941.

*Jour. Amer. Med. Assoc., 116:2747. 1941.

SEED CHARACTERS AND LINT PRODUCTION

Relation of Naked Seed to Lint Percentage, Lint Index, Staple Length, and Seed Index in Sea Island Cotton*

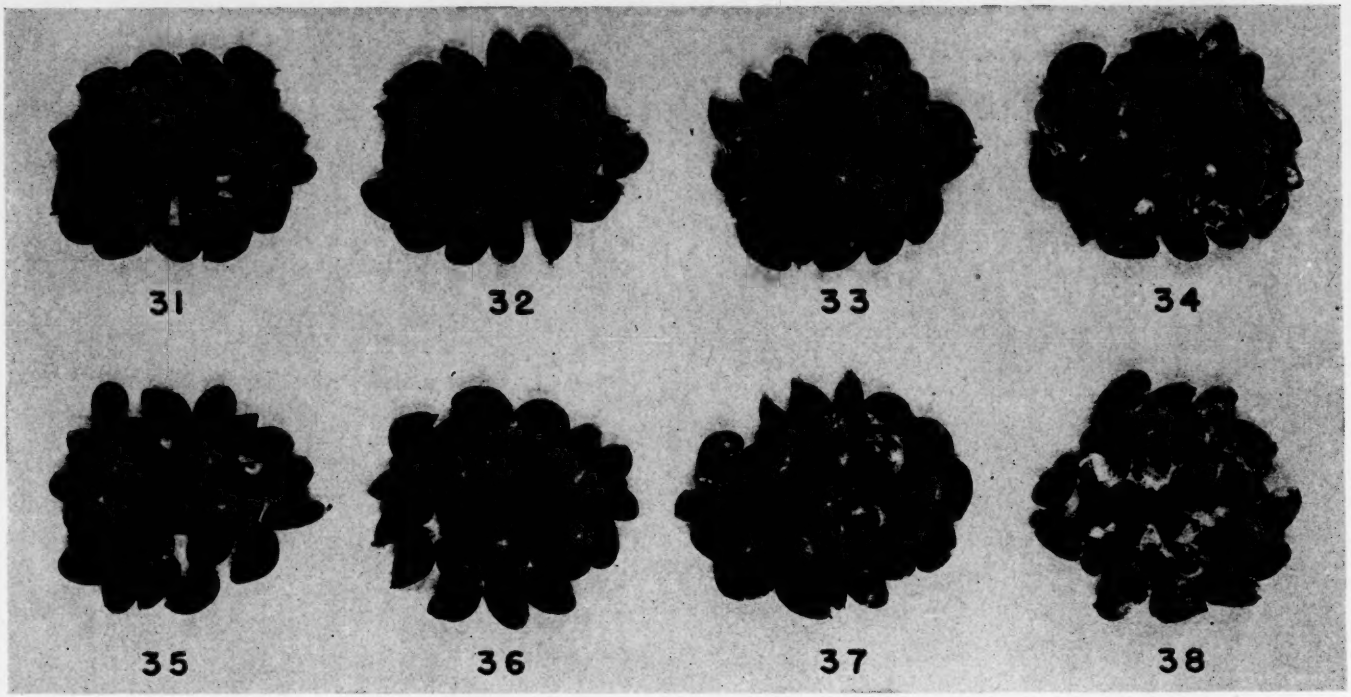
J. O. WARE, W. H. JENKINS, AND D. C. HARRELL†

SEA island cotton growers and specialists interested in the maintenance and improvement of the quality of this crop have for many years noted that tuftless or naked seed is borne by occasional plants. Such seeds, free of all fuzz, even small tufts at pointed or rounded end, have been considered to be associated with certain undesirable economic characteristics persisting in these plants. In the maintenance of seed stocks and in breeding for improvement of sea island cotton such plants have been rogued from the fields and generally avoided in stocks used for breeding. Tuftless seed in sea island cotton (*Gossypium barbadense*) are morphologically similar to naked seed in upland (*G. hirsutum*). Considerable work has been done in the latter species on the heritable relations of the seed cover to lint percentage, lint index and seed index. Ware[8,9,10] recently reviewed this work in upland cotton and reported further studies. The previous work largely involved only the relation of seed cover to lint percentage, based on crosses in which one parent strain had naked seed and a very sparse condition of lint. Lint percentages of homozygous naked seed strains in upland cotton range as low as zero and seldom higher than 10 to 12 per cent. However, as shown by Winters et al,[11] naked seed in upland cotton may be associated in homozygous condition with as much as 22 per cent lint. The sea island work reported in this paper is concerned with plants having a low lint percentage (ratio of lint weight to unginned seed-cotton weight) but non-sparse condition of lint (seeds relatively hairy). In fields of sea island, the writers have observed plants having a pronounced condition of lint sparseness. It appears that this condition is different from that referred to by those who have reported the tuftless condition of sea island seed and the bearing of this attribute on the deterioration or "running out" of varieties. These observers appear to have had in mind principally tuftless seed in types not having sparse lint. Otherwise the sparse condition of the lint would have been the marker for elimination rather than the absence of fuzz. Thornton[6] in discussing sea island plant selection for conditions in Barbados B.W.I., in 1906 advised that the seeds should be tipped with fuzz at one or both ends. In the *Agricultural News*[1], a West Indian paper of that period, reference was made to this matter. It was stated that clean and black seed without any indication of fuzz at either end was being found in the current crop, that these particular seed produced only a small quantity of lint at the apex and that a large proportion of the fibers were weak. This paper further suggested that such seed should be picked out of the planting stocks and only seed with a green fuzz at one end or both ends should be planted.

Foaden[4] in 1905 in Egypt referred to the admixture of Hindi cotton in commercial Egyptian (*Gossypium barba-*

*Contribution from Division of Cotton and Other Fiber Crops and Diseases, U. S. Dept. of Agriculture, and the Pee Dee Station of the South Carolina Agricultural Experiment Station, Florence, S. C., cooperating.

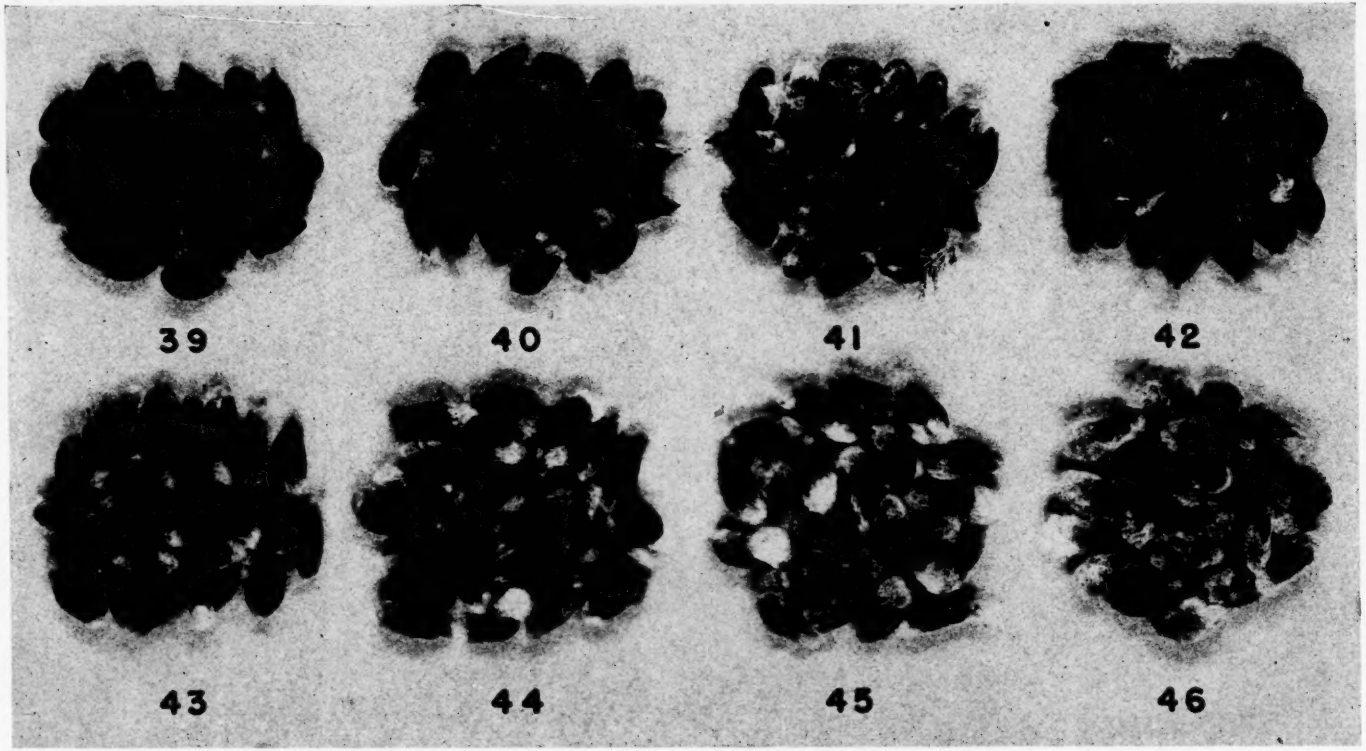
†Senior Agronomist, Division of Cotton and Other Fiber Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Dept. of Agriculture; Agronomist, and Assistant Agronomist, Pee Dee Experiment Station, Florence, S. C., respectively. Mr. Harrell is now in military service.



GRADES OF SEA ISLAND COTTON SEED—31-38

Figure 16

For the purpose of this study 16 grades and four sub-grades of extent of fuzz and attachments of basal lint segments in Sea Island cotton have been established. The first eight grades are shown here; for description see page 156. The sub-grades are not illustrated but are described in the discussion and in the footnotes to Table III.



SEA ISLAND COTTON GRADES—39-46

Figure 17

These samples complete the series of 16 grades. Numbers below 31 have been assigned to grades in upland cotton and in certain hybrids. The numbers assigned are purely arbitrary. See description, page 158.

dense) varieties and particularly in Afifi. The Hindi cotton had fuzzless seed, the gin outturn was low and the fiber inferior and short. After the introduction of Egyptian cotton into California and Arizona, Cook in 1909 and in 1911 discussed Hindi cotton[2,3] and pointed out the danger of the occurrence of Hindi or some of its hybrids in this new crop in this country. Cook[2] mentions the so-called "bull cotton," a type occasionally found in sea island and resembling the Hindi type. Orton[5] in advising as to seed selection for sea island in 1907 stated that the seed should be small but well filled, black and with a small green tuft at the end. He said that bare seeds were associated with a low ginning rate, and that the appearance of such seeds as well as certain other plant characteristics was usually taken as an indication that the strain was "running out." Orton also mentions the "bull cotton" and the necessity of roguing it out of the fields. No coarse types of this kind occur in the present sea island crop except as resulting from chance hybridization with upland. The "bull cotton" formerly found in sea island may have had this origin. Tyler[7] in 1910 stated that it was a general belief at that time among cotton planters and breeders that entirely naked seeds in both upland and sea island should be picked out and discarded from choice seed intended for planting.

Material and Methods

In 1936 sea island plants having seed with fuzz tuft variations and without fuzz were selected and planted at the Pee Dee Experiment Station at Florence, South Carolina, as a part of the cotton genetics work there. These plants were taken from four varieties — Seabrook, Westberry, Bleak Hall, and Andrews— which had been self-pollinated in 1935 and 1936. In 1937, 438 plants were grown and classified for seed fuzz grade, staple length, lint percentage, seed index and lint index. The staple length was determined by pulling lint from seeds and measuring to the nearest 1/32 inch. The seed cotton was ginned on a small roller gin and the lint percentage, seed index, and lint index computed from weights taken at ginning. From the seed of this material as well as from other sea island seed stock, a set of standards representing the range as to position and amount of fuzz on seed coat was set up and numbered from 31 to 46.* Photographs of the seed fuzz grades are shown in Figures 16-17. A description of these grades is given below. The 1937 results are shown in Table I. In 1938, plants representing a range of the seed fuzz grades were taken from the four varieties grown in 1937 and planted. In Table II a classification (similar to that of Table I) of 528 plants of the 1938 growth is shown. The seed fuzz grades of the parent plants are indicated also in this table. In 1942, 196 Gaddis sea island plants (98 of strain 19 and 98 of strain 28) were harvested at the Coastal Plain Experiment Station, Tifton, Georgia, and classified in a similar way. The results of the Gaddis plants are reported in Table III. Also in 1943, observations have been made on 63 Gaddis progeny rows.†

Description of Seed Fuzz Grades

The following description of seed fuzz grades applies to grades 31 to 46 shown in Figures 16 and 17.

31. Naked seed-coat, no fuzz, and practically no short basal segments of lint. Obtained from sea island plants having sparse lint.
32. Naked seed-coat, no fuzz, few short basal segments of lint mostly on chalazal or rounded end.
33. Naked seed-coat, no fuzz, frequent appearance of short basal segments of lint on chalazal end and some of these segments scattered over most of seed-coat.
34. Naked seed-coat, no fuzz, thick areas of short basal segments of lint mostly on chalazal end but prevailing more scatteringly over much of seed-coat.
35. Naked seed-coat except vestigal or vanishing tuft of fuzz on hilum or pointed end of seed. Few scattering short basal seg-

*The numbering of these grades is arbitrary. Upland seed coat grades are numbered 1-20,[8] the seed grades of certain hybrids[9] from 21-30.

†J. G. Jenkins, Associate Agronomist, Georgia Coastal Plain Experiment Station, Tifton, Georgia, supplied the 1942 Gaddis material and made the observations of 1943.

ments of lint over seed-coat.

36. Naked seed-coat except small tuft of fuzz on hilum end. Few scattering short basal segments of lint but concentrated somewhat on chalazal end.
37. Naked seed-coat except small tuft of fuzz on hilum end. Rather thick areas of short basal segments of lint mostly on chalazal end but prevailing more scatteringly over much of seed-coat.
38. Naked seed-coat except small tuft of fuzz on hilum end. Very thick areas of short basal segments of lint mostly on chalazal end but prevailing more scatteringly over most of seed-coat.
39. Naked seed-coat except medium-size tuft of fuzz on hilum end. Few scattering short basal segments of lint over seed-coat.
40. Naked seed-coat except medium-size tuft of fuzz on hilum end. Frequent appearnace of short basal segments of lint on chalazal end and some of these segments scattered over most of seed-coat.
41. Naked seed-coat evcept medium size tuft of fuzz on hilum end. Very thick areas of short basal segments of lint mostly on chalazal end but prevailing more scatteringly over most of seed-coat.
42. Naked seed-coat except small tufts of fuzz on both hilum and chalazal ends. Some appearance of short basal segments of lint on most of seed-coat area but concentrated somewhat on chalazal end.
43. Naked seed-coat except medium size tufts of fuzz on both hilum and chalazal ends. Very thick areas of short basal segments of lint mostly on chalazal end but prevailing much more scatteringly over most of seed-coat.
44. Naked seed-coat except medium to large-size tufts of fuzz on both hilum and chalazal ends. Very thick and heavy areas of short basal segments of lint mostly on chalazal end and the lint segments prevailing rather abundantly over most of seed-coat.
45. Naked seed-coat except very large-size tufts of fuzz on both hilum and chalazal ends. Very thick and heavy areas of short basal segments of lint mostly on chalazal end. The lint segments are rather pronounced over most of seed-coat.
46. Partly naked seed-coat. Very large tufts of fuzz on both hilum and chalazal ends and some fuzz covering over much of seed-coat. Heavy areas of short basal segments of lint on chalazal end as well as on much of the seed-coat. Fuzzless areas also show presence of considerable attachments of the short lint segments.

In grading the seed from the 1942 Gaddis sea island plants, a few variations from those represented in Figure 16 were found. These grades were designated as 34A, 34B, 34C, and 35A and are described in Table III and its footnotes.

Results

In Table I, the data from sea island plants of the 1937 growth were broken down into three groups for seed fuzz grade: the three fuzzless grades, the four grades having a hilum tuft of fuzz, and the five grades having both hilum and chalazal tufts (grade 46 possessed additional fuzz covering).

Of the four varieties of sea island studied in 1937, Seabrook was the only variety from which plants having fuzzless seed were studied. Plants of the other three varieties, Westberry, Bleak Hall, and Andrews, fall into two groups, one with the fuzz tuft at one end and the other with the fuzz tuft at both ends. Westberry and Andrews had somewhat shorter staple and much higher lint percentage and lint index than Seabrook. Bleak Hall had the longest staple and the lowest lint percentage and lint index of the four varieties. Within any one of the four varieties, there was little difference in the level of the four determinations between the hilum fuzz, and the hilum and chalazal fuzz groups, except Bleak Hall which had somewhat higher lint percentage and somewhat lower seed index in the former group. The tendency for higher lint percentage and lower seed index of this variety also occurred in Grade 43 of the hilum and chalazal fuzz group. This grade has the highest lint index of the several Bleak Hall grades. On the other hand, the fuzzless group, which is represented (as mentioned above) only by plants of the Seabrook variety, shows when compared with the two tufted groups of Seabrook lower lint percentage as well as lower lint index associated with naked seeds. The fuzzless group has a slightly longer staple and a somewhat lower seed index, however, than the other fuzz groups of Seabrook.

In Table II, the data of the sea island plants of the 1938 growth were broken down in the same manner as those of the 1937 growth. However, the actual grades that appeared vary slightly. Three grades, 33, 34, and 35, are combined in

Table I. Relation of Seed Fuzz, Staple Length, Lint Percentage, Seed Index, and Lint Index in Sea Island Cotton, 1937 Growth

Varieties and Characters Studied	Seed Grades Based on Amount of Fuzz and Adhering Basal Segments of Lint 1/																		
	32	33	34	Av.	36	39	40	41	Av.	42	43	44	45	46	Av.				
	Fuzzless				Hilum Fuzz Tuft					Hilum & Chalazal Fuzz Tufts 2/									
Staple Length 3/																			
Seabrook	52.9	55.2	54.0	54.3	55.4	-	52.6	52.3	52.8	-	51.9	53.0	53.0	53.0	52.8				
Westberry	-	-	-	-	49.3	51.0	51.0	51.6	50.6	50.0	51.5	50.2	-	-	50.5				
Bleak Hall	-	-	-	-	-	-	55.7	55.0	55.1	-	54.0	59.4	58.0	57.3	57.9				
Andrews	-	-	-	-	-	-	48.4	48.4	48.4	48.0	47.2	47.9	48.2	-	47.6				
Lint Percentage																			
Seabrook	26.5	24.1	21.8	24.7	26.3	-	28.2	29.9	29.0	-	26.3	29.1	28.4	29.8	28.7				
Westberry	-	-	-	-	32.1	32.3	31.8	33.6	32.5	32.5	33.1	31.6	-	-	32.0				
Bleak Hall	-	-	-	-	-	-	25.8	25.9	25.9	-	26.1	22.4	22.2	23.3	22.7				
Andrews	-	-	-	-	-	-	32.5	33.7	33.0	34.0	33.7	33.1	32.8	-	33.5				
Seed Index 4/																			
Seabrook	11.62	12.99	13.27	12.54	14.81	-	14.68	14.09	14.32	-	14.53	15.10	14.85	14.27	14.87				
Westberry	-	-	-	-	12.63	12.25	12.73	13.83	12.98	12.76	12.32	13.30	-	-	13.03				
Bleak Hall	-	-	-	-	-	-	11.71	11.65	11.66	-	12.64	13.77	13.12	13.39	13.19				
Andrews	-	-	-	-	-	-	12.94	12.14	12.58	12.45	12.38	12.23	12.27	-	12.31				
Lint Index 5/																			
Seabrook	4.23	4.07	3.72	4.09	5.30	-	5.74	5.99	5.85	-	5.19	6.19	5.88	6.05	5.97				
Westberry	-	-	-	-	5.97	5.83	5.93	6.41	6.08	6.14	6.09	6.15	-	-	6.13				
Bleak Hall	-	-	-	-	-	-	4.07	4.08	4.08	-	4.47	3.88	3.77	4.06	3.88				
Andrews	-	-	-	-	-	-	6.20	6.17	6.18	6.40	6.29	6.06	5.99	-	6.19				
No. of Plants Av'd 6/																			
Seabrook	22	35	6	63	5	-	10	26	41	-	7	29	11	7	54				
Westberry	-	-	-	-	20	4	14	16	54	1	4	12	-	-	17				
Bleak Hall	-	-	-	-	-	-	6	34	40	-	2	7	23	7	39				
Andrews	-	-	-	-	-	-	50	41	91	6	73	56	4	-	139				

1/ See Description of grades for seed fuzz or seed coat fiber attachments, page __

2/ Additional covering on highest grade

3/ In 32nds of inch, only numerator of fraction reported

4/ Seed index, grams per 100 seeds; Lint index, grams of lint from 100 seeds

5/ In the three "average" columns, subtotals are shown instead of averages

Table II . . Relation of Seed Fuzz, Staple Length, Lint Percentage, Seed Index, and Lint Index in Sea Island Cotton, 1938 Growth

Varieties and Characters Studied	Seed Grades Based on Amount of Fuzz and Adhering Basal Segments of Lint 1/																		
	33	34	35	Av.	37	38	40	41	Av.	43	44	45	46	Av.					
	Fuzzless				Hilum Fuzz Tuft					Hilum & Chalazal Fuzz Tufts 2/									
Staple Length 3/																			
Seabrook (Fuzzless) 4/	47.7	50.9	47.0	49.3	-	-	-	-	-	-	-	-	-	-					
Seabrook (tufted) 5/	51.2	50.9	-	51.0	50.0	50.5	47.3	50.4	50.2	47.4	50.1	-	47.3	48.3					
Westberry 6/	-	-	-	-	-	47.2	49.6	47.8	48.3	48.9	-	-	-	48.9					
Bleak Hall 7/	-	-	-	-	-	-	-	55.0	55.0	56.5	56.9	59.0	-	57.1					
Andrews 8/	-	-	-	-	-	-	45.6	46.5	46.4	43.7	43.6	43.7	-	44.8					
Lint Percentage																			
Seabrook (Fuzzless)	27.3	23.1	26.2	25.2	-	-	-	-	-	-	-	-	-	-					
Seabrook (tufted)	21.5	25.0	-	23.8	29.1	28.2	28.6	30.0	29.7	27.0	31.2	-	29.5	28.6					
Westberry	-	-	-	-	-	32.0	31.5	31.9	31.8	30.9	-	-	-	30.9					
Bleak Hall	-	-	-	-	-	-	-	26.5	26.5	22.7	20.4	23.2	-	21.2					
Andrews	-	-	-	-	-	32.9	32.7	32.8	32.2	31.2	30.8	-	31.8						
Seed Index 9/																			
Seabrook (Fuzzless)	10.87	12.54	11.10	11.71	-	-	-	-	-	-	-	-	-	-					
Seabrook (tufted)	14.42	13.04	-	13.49	14.44	13.76	13.14	13.53	13.54	13.11	13.53	-	12.91	13.23					
Westberry	-	-	-	-	-	11.78	12.21	12.15	12.09	11.86	-	-	-	11.86					
Bleak Hall	-	-	-	-	-	-	-	12.30	12.30	11.67	11.95	11.91	-	11.88					
Andrews	-	-	-	-	-	11.43	11.68	11.47	11.44	11.71	11.51	-	11.54						
Lint Index 9/																			
Seabrook (Fuzzless)	4.09	3.75	3.94	3.92	-	-	-	-	-	-	-	-	-	-					
Seabrook (tufted)	3.93	4.33	-	4.19	6.01	5.38	5.24	5.52	5.49	4.87	6.14	-	5.40	5.34					
Westberry	-	-	-	-	-	5.43	5.61	5.71	5.61	5.29	-	-	-	5.29					
Bleak Hall	-	-	-	-	-	-	-	4.44	4.44	3.48	3.08	3.59	-	3.22					
Andrews	-	-	-	-	-	5.66	5.60	5.60	5.45	5.31	5.09	-	5.38						
No. of Plants Av'd 10/																			
Seabrook (Fuzzless)	125	127	1	253	-	-	-	-	-	-	-	-	-	-					
Seabrook (tufted)	5	10	-	15	1	5	4	51	61	7	4	-	1	12					
Westberry	-	-	-	-	-	12	20	24	56	16	-	-	-	16					
Bleak Hall	-	-	-	-	-	-	-	1	1	4	12	2	-	18					
Andrews	-	-	-	-	-	5	40	45	30	18	3	-	51						

1/ See description of grades for seed fuzz or seed coat fiber attachments, page __

2/ Additional covering on highest grade

3/ In 32nds of inch, only numerator of fraction reported

4/ Parent grades combined, 32, 33, 34

5/ " " " 36; 40, 41, 43, 45

6/ Parent grades combined, 40, 42, 43

7/ Only one parent grade, 44

8/ Parent grades combined, 40, 41, 43, 44

9/ Seed index, grams per 100 seeds; lint index, grams of lint from 100 seeds

10/ In the three "average" columns, subtotals are shown instead of averages

the fuzzless group, four grades, 37, 38, 40, and 41, in the hilum fuzz group, and four grades, 43, 44, 45, and 46, in the hilum and chalazal fuzz group. In the Westberry, Bleak Hall, and Andrews varieties only tufted seeds were planted and only such seeds were produced in 1938. The lint length of Westberry was slightly longer than Seabrook in two of the grades, but averaged somewhat shorter in all the tufted grades of Seabrook for which there are comparisons. The staple length of Andrews was definitely shorter than Seabrook and along with Westberry, Andrews was higher than Seabrook in lint percentage. The two varieties were also slightly higher than the Seabrook tufted groups in lint index. Bleak Hall had longer staple, lower lint percentage and lower lint index than the other three varieties. Seabrook had the largest seed and Andrews, the smallest seed of the four varieties. Seabrook had the largest seed in 1937.

All Seabrook plants having fuzzless seed in 1937 reproduced fuzzless seed in 1938. Fuzzless segregates also appeared in 1938 in progenies from the 1937 Seabrook tufted stocks. These two results indicate that the fuzzless condition in sea island is recessive. In the 1938 fuzzless progenies from the 1937 fuzzless Seabrook, the staple length, seed index, and lint index are somewhat lower and the lint percentage slightly higher than in the parents of the previous year. The staple in 1938 was 5/32" shorter, the lint percentage .5 per cent higher, the seed index 0.83 grams lower, and the lint index 0.17 grams lower than in 1937. Also this group had shorter staple, lower seed index, lower lint index, and higher lint percentage than occurred in the fuzzless group segregating in 1938 from the 1937 tufted groups. However, the 1938 fuzzless segregates had definitely lower lint percentage and lint index than the tufted segregates of that year. The seed index of the 1938 segregates is at about the same level in the fuzzless and the tufted groups, but the staple length is slightly longer in the former group.

Some of the 98 Gaddis-19 plants shown in Table III had a definite hilum fuzz tuft; 27 of these plants had no fuzz whatever, but 71 had some form of chalazal fuzz. As between the two groups, the seed index, and the lint index did not vary materially. Of the 98 plants of Gaddis-28, 44 had no fuzz, 42 had chalazal fuzz, 6 had vestigal hilum fuzz, and 6 had true hilum fuzz. In the group with true hilum fuzz on the one hand and the three other groups on the other hand, rather small differences in staple length and seed index appear. The plants of the chalazal fuzz group had slightly longer staple than the other three groups, but the plants of the hilum fuzz group had the lowest seed index. The lint percentage of the hilum fuzz group is higher than in the other groups, but there is not much difference in the lint index among the groups. The lower seed index of the hilum fuzz group is

Table III. Relation of Seed Fuzz, Staple Length, Lint Percentage, Seed Index, and Lint Index in Gaddis Sea Island Cotton, 1938 Growth

Varieties and Characters Studied	Seed Grades Based on Amount of Fuzz and During Basal Segments of Lint																			
	32	33	36	Av.	34A	34B	34C	Av.	35	35A	Av.	37	38	42	Av.					
	Fuzzless				Chalazal Fuzz Tuft 1/				Vestigal Hilum Tuft 2/			Hilum Fuzz Tuft 3/								
Gaddis 19																				
Staple Length	—	45.9	46.0	46.0	46.2	46.4	47.9	46.5	—	—	—	—	—	—	—					
Lint Percentage	—	26.7	27.3	27.3	26.7	26.6	27.1	26.7	—	—	—	—	—	—	—					
Seed Index	—	11.50	11.67	11.59	11.63	11.14	11.66	11.45	—	—	—	—	—	—	—					
Lint Index	—	4.18	4.46	4.34	4.23	4.03	4.26	4.17	—	—	—	—	—	—	—					
No. of Plants Av'd	—	12	15	27	38	23	10	71	—	—	—	—	—	—	—					
Gaddis 28																				
Staple Length	43.5	43.9	45.2	44.0	45.6	46.2	—	45.8	43.2	47.0	43.8	44.0	39.0	44.7	43.6					
Lint Percentage,	29.8	29.8	28.5	29.6	27.6	26.8	—	27.4	31.8	21.7	30.1	31.2	33.1	31.7	31.8					
Seed Index	10.53	10.10	10.20	10.23	10.90	10.61	—	10.81	10.48	12.52	10.82	10.20	10.34	9.33	9.79					
Lint Index	4.43	4.28	4.09	4.28	4.15	3.87	—	4.07	4.89	3.47	4.65	4.55	5.09	4.42	4.58					
No. of Plants Av'd	12	25	7	44	29	13	—	42	5	1	6	2	1	3	6					

1/ Chalazal fuzz tuft group has patches of fuzz on rounded end of seed. However, this condition does not occur on all seeds the others being naked. Size of patches and abundance of lint basal segments increase from 34A to 34C.

2/ Grade 35A also has patches of fuzz on rounded end of some seeds

3/ Grade 42 also has Chalazal fuzz tuft

reflected in higher lint percentage. The numbers of plants in the vestigal hilum fuzz or the hilum fuzz groups are rather small to justify conclusions, however.

In a study of 63 Gaddis progeny rows at Tifton, Georgia, in 1943, considerable variation in amount and position of fuzz on seeds was noted among these progenies. The range was from naked seed to a condition of considerable fuzz. There were little or no tufts or fuzz attachments on the hilum end of any of the seed. The fuzz was confined mostly to the chalazal end with some hairs scattered over most of the seed-coat. No definite association appeared to occur between seed fuzz and lint percentage.

Gaddis is an earlier developing variety than Seabrook, the standard sea island variety in this country. However, Gaddis has shorter staple, lower lint percentage, lower seed index and lower lint index than Seabrook. Some or all of these characteristics are usually associated with earlier varieties. It has been thought particularly that lower lint percentage and lower lint index in Gaddis are associated with the naked seeds or with seeds not having the definite hilum, or hilum and chalazal tufts of fuzz. In Seabrook, such association is the case, but in Gaddis lint percentage or lint index appears not to be definitely lower in progeny populations having naked seeds.

Summary

Samples of seed cotton from individual plants of the Seabrook, Westberry, Bleak Hill, Andrews, and Gaddis varieties of sea island cotton were analyzed for the purpose of determining the relation of naked seed and seed fuzz tufts to lint percentage, lint index, staple length, and seed index.

In the Westberry, Bleak Hall, and Andrews varieties, the location and size of the tufts—whether on one or both ends of the seed or large or small—did not materially affect the level of lint percentage, lint index, staple length, or seed index. The magnitude of each of these characteristics was dependent on the variety.

The fuzzless or naked seed individuals of the Seabrook variety produced lint percentage and lint index values that were definitely lower than those of the normal seed fuzz forms in this variety. Staple length and seed index were not affected much by the condition of the seed fuzz in Seabrook.

The Gaddis variety has a much larger proportion of naked seeds and has shorter staple, lower lint percentage, lint index and seed index than Seabrook, but there appeared to be no significant differences in the levels of these characteristics—staple length, lint percentage, lint index, and seed index—to the different fuzz grades. Results of Gaddis progeny rows in 1943 verified this relationship.

Naked seed in sea island appeared to be a recessive character.

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